Bridge Building:
Focus: Structural Engineering
Grades: suggested for grades K-12

Bridge Building

The purpose for the bridge building experience is to make students aware of the field of civil engineering. Introduce students to an engineer and give them an overview of some of the kinds of things an engineer has to deal with on a day-to-day basis. The basic idea is to give the students hands on experiences with building a structure such as a bridge with various types of mediums. An actual bridge is brought in the classroom; giving the students the opportunity to work cooperatively, put the bridge together and cross it when it is completed. A wizard (scientist or engineer) explains direction to the students then identifies the parts of the bridge and finally the bridge is built then placed on four chairs for the children to cross. When the bridge is completed, the wizard has a discussion with the students relative to what they have learned and then they break into groups dismantle the bridge.

Bridge Building K-6

The basic concept is to enhance the student's knowledge base in the area of civil engineering. An engineer is a person that works to build and dismantle things. They work from a blue print or plan to create various types of structures.
The responsibilities of a civil engineer are planning, designing, construction, or management of machinery on roads, bridges, buildings, etc. Our goal is to give the student a different prospective on the life of an engineer and help the student make an alternative career decision.

Teacher interested in having this demonstration in their classrooms will contact the Wright - Patterson Air Force Base Educational outreach office. The Program director will be happy to assist you in scheduling a wizard to visit your classroom for a one-hour presentation. The teacher is sent a pre-activity packet one week prior to the actual presentation to formularize the students with lesson preceding the visit. The pre-activity consists of vocabulary, a lesson overview, description of an engineer and the materials used in the demo.

Once the demonstration is scheduled, the wizard visits the site that the demo will be held and the students will partake in hands on experiences that will help with future decision for a stable career.

Academic Content Standards:

These K-8 grade level indicators for Physical science & Science and Technology are parallel the Ohio Achievement test.

Kindergarten: 1. Explore that some materials can be used over and over again (e.g., plastic or glass containers, cardboard boxes and tubes).

Grade One:
1. Explore that some kinds of materials are better suited that other for making something new (e.g., the building materials used in the three little pigs).
2. Explain that when trying to build something or get something to work better, it helps to follow directions and ask someone who has done it before.
6. Investigate that tools are used to help make things and some things cannot be made without tools.
7. Explore that several steps are usually needed to make things (e.g., building with blocks).
8. Investigate that when parts are put together they can do things that they could not do by themselves (e.g., Blocks gears and wheels).

Grade Two:
3. Predict how building or trying something new might affect other people and the environment.
4. Communicate orally, pictorially, or in written form the design process used to make something.

Grade Three:
4. Use a simple design process to solve a problem (e.g., identifies a problem, identify possible solutions and design a solution).

Grade Four:
1. Explain how technology from different areas (e.g., transportation, communication, nutrition, healthcare, agriculture, entertainment and manufacturing) had improved human lives.
2. Investigate how technology and inventions change to meet people's needs and wants.
3. Describe, illustrate, and evaluate the design process used to solve a problem.

Grade Five:
2. Revise an existing design used to solve a problem based on peer review.
3. Explain how the solution to one problem may create other problems.

Grade six:
4. Explain how the usefulness of manufactured parts of an object depends on how well their properties allow them to fit and interact with other material.
5. Design and build a product or create a solution to a problem given one constraint (e.g., limits of cost and time for design and production, supply of materials and environmental effects).

Grade Seven:
4. Design and build a product or create a solution to a problem given two constraint (e.g., limits of cost and time for design and production, supply of materials and environmental effects).

Grade Eight: 3. Design and build a product or create a solution to a problem given two constraint (e.g., limits of cost and time for design and production, supply of materials and environmental effects).

4. Evaluate the overall effectiveness of a product design or solution.

Grade Nine: 2. Identify a problem or need, propose design and choose among alternative solutions for the problem.

3. Explain why a design should be continually assessed and the ideas of the

3. Design should be tested, adapted, and refined.

Grade Ten: Explain that when evaluating a design for a device or process, thought should be given to how it will be manufactured, operated, maintained, replaced and disposed of in addition to who will sell, operate and take care of it. Explain hoe the costs associated with these considerations may introduce additional constraints on the design.

Grade Eleven: **No Indicators present in this grade for Life science standards**

Grade Twelve: **No Indicators present in this grade for Life science standards**

Bridge Pictures

I. Hida River Bridge in **Japan (Small Truss bridge)** Similar To the bridge constructed in the class**.**

2. **Tonegawa River Bridge** in **Japan (Larger Truss bridge)**

3. **Francis Scott Key Bridge** in **Baltimore (Arched Truss Bridge)**

4 & **5. Pont Du Gard** in **Southern France (Stone Arch -Aqueduct)** this is one of the oldest bridges in the world, which is still in good condition Built by the Romans about 60 BCE.

6. Kintai Bridge in **Japan (Pedestrian Arch Bridge)**

7. **Fehmarnsund Bridge** in **(I think) Germany (Tied Arch -Train Bridge)**

8. **Avon River Bridge** in **England (Concrete Girder Bridge)**

9. **New River Bridge in West Virginia (Steel Arch**) this is the largest single arch bridge.

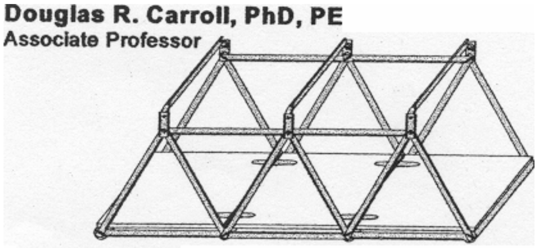
10. **Pedestrian Cable Stayed Bridge near** in **Mannheim**

11. **Brooklyn Bridge** in **New York** (**Suspension with Stone Supports**) this was the first really good suspension bridge built -about 1908.

12. **Tacoma Narrows** in **Washington State** (Suspension) this is after it was rebuilt -the original had slender girder stiffeners along the span, rather than the deep trusses on this bridge.

13 & 14. **Golden Gate** in **California** (Suspension) during the gold rush, ship captains would sail between the mountains into the San Francisco bay to deliver supplies and pick up gold. They referred to the entrance into the bay as the golden gate, hence the name of the bridge built across.

Douglas R. Carroll, PhD, PE
Associate Professor



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ABSTRACT

A one-hour presentation was developed to get elementary school students interested in engineering. The presentation begins with the students building a six-foot long structurally sound bridge which they can crawl across. A pictorial presentation helps them learn to identify some of the different types of bridges: truss, stone arch, steel arch, concrete girder, cable-stayed, and suspension. They are introduced to the fundamental engineering concepts of tension and compression. Demonstrating that if a tension member is replaced with a chain then the bridge is still strong, but if a compression member is replaced with a chain the bridge will collapse reinforces these concepts. The presentation is designed to be fun for the children and the presenter, and to introduce the children to the field of engineering.

INTRODUCTION -OBJECTIVE

The objective of this project was to develop a means of getting elementary school children interested in engineering. Most teachers consider engineering to be a good career choice and would like to include some engineering units in their lessons, but there are very limited less<? No plan materials for them to draw from. As a contrast, there are many resources for biology, chemistry, geology, and physics lessons, so elementary schools tend to focus on the pure sciences rather than engineering. In order to expose elementary school children to engineering, we need to develop materials for their teachers to draw from, and we need to do it in a non-threatening manner.

Engineers work in many areas, on many technical problems, and it would not be possible to present all of the engineering fields in one lesson. This project is oriented toward civil engineering. The children are given an introduction into how bridges are designed and built.

ORIGIN

The project originated when my youngest son asked me to bring "some sort of engineering thing" to his class for father's week. I had several weeks warning, so I designed and built a truss bridge kit. The children would build the bridge, which was 6 feet long and 2 feet wide, and then take turns crawling across it. My older son asked that I bring it to his class, and then other teachers began asking me to come to their classes. The children and teachers enjoyed it, and I began to develop a presentation the teachers could use to meet some of the goals in their curriculum. I began building bridge kits for other engineers to use, and there are currently hundreds of engineers around the country using this kit to introduce children to engineering.

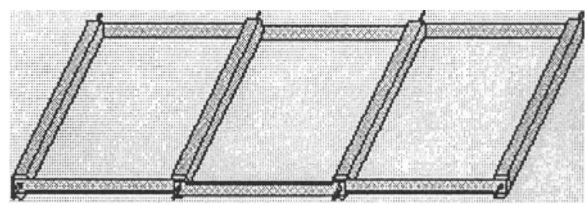
BRIDGE DESIGN

The bridge was designed to have 29 major pieces, so each student in the classroom will get to put a major piece into the bridge. An equilateral truss arrangement was used for simplicity in construction, so that any truss member would fit in any position. The major pieces are 4 floor beams, 22 truss members, and 3 lateral braces. Each of these pieces is approximately two feet long, and shaped as shown in Figure 1.

The truss members are all made from 314 X 314 X 118 aluminum angles (or larger), the floor beams are made from wooden hand railing, and the lateral bracing across the top is made from *Y2* X *Y2* X 118 aluminum angles. There are 26 pieces of hardware, consisting of brackets and wing nuts. The entire bridge frame weighs 10 to 20 lbs, and can carry a 200 lb person. All of the pieces for the frame, including the hardware, fit nicely into a softball bag. The decking was made from 1/2-inch plywood, hinged in two places for ease of transport. It weighs about 20 Ibs. The design is lightweight and compact enough that one person can carry everything into the classroom in one trip.

PRESENTATION

I begin the presentation by saying that the first thing I need everyone to do is help me build a bridge. The students form a line and I hand about one major piece of the bridge to each student. Each student will get to put his or her piece in the bridge so that no one feels left out. We start with two floor beams, connected by two of the truss members, making a square on the floor. The other floor beams are then added, making two feet by six feet rectangle on the floor, as shown in Figure 2. No hardware has been used to this point, and I need several students to hold all the pieces in place, which keeps them involved.



The floor beams were made from wood hand railing, which has a flat side, and I tell them we need the flat side up so the decking will have a flat place to rest on. It is important to use the correct terminology during the presentation so the students learn the engineering vocabulary. They can use the terms <u>floor beams</u>, <u>truss members</u> and <u>decking</u> as easily as boards and metal pieces. It is also important to point out that truss members are made from aluminum, not steel, and not "metal".

The next step in building the bridge is to begin erecting the trusses, as shown in Figure 3. I select two children with truss members, and say, "I need you two to do something a little different. I have them put their two truss members on the ends of the floor beams, and point them straight up. Then I ask them to lean their members in, and line up the holes, and slide the large bolt on one of the brackets through the holes. One of them will need to stay kneeling beside the bridge, holding the bracket straight up as shown in figure. There are no wings nuts on the bridge at this point.

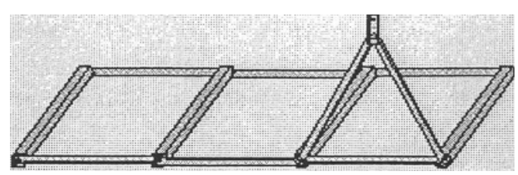


Figure 3. Start erecting Trusses.

For the younger students, I usually ask, "what shape have we made?" Learning shapes is a major theme in elementary school mathematics, and talking about the shapes in the bridge helps reinforce what the teacher has been teaching them. If you look carefully at the completed bridge you can find squares, rectangles, triangles, trapezoids, rhombus, and parallelograms. The next step is to choose pairs of students, and have them erect the other five triangles. After building all of the triangles, the bridge will look like Figure 4. At this point I hand out eight of the large wing nuts, and have the children screw then on the bottom floor beam connections. There are still members to be added to the top, so they cannot put wing nuts on the top connections.

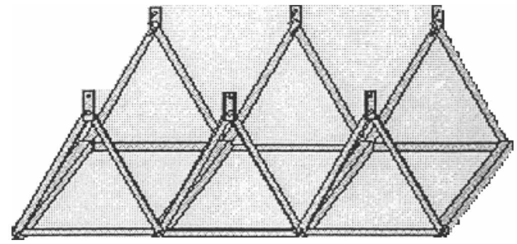


Figure 4. Completed Trusses

There are still four truss members left at this point, and for most people it is not obvious where they go. I select one of the children with a truss member and ask, "Where do you think your piece goes?" I have him/her go out in the middle of the bridge and experiment and figure out where it should go. The other children will offer lots of suggestions, and they will figure it out quickly. Once the last four truss members are in place, I hand out the other six large wing nuts and have the children screw them on the top connections. At this point the bridge will look like Figure 5.

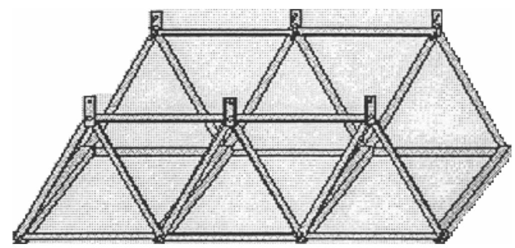


Figure 5. Trusses Erected

Once the hardware is installed, the bridge is fairly strong, but there are still some lateral stability problems with the trusses. The final step in constructing the frame is to install the three lateral braces across the top as shown in Figure 6. I ask them "Does it look like a bridge?" I point out that there are big holes between the floor beams, and that people might fall through the bridge if we left it like that. We need a decking for the bridge. Most bridges have a concrete decking, but carrying a concrete decking into the class would be too heavy, so our bridge will have a wooden decking. The students then stand back while I slide the decking place. (The hinged design makes it a potential hazard for pinching fingers).

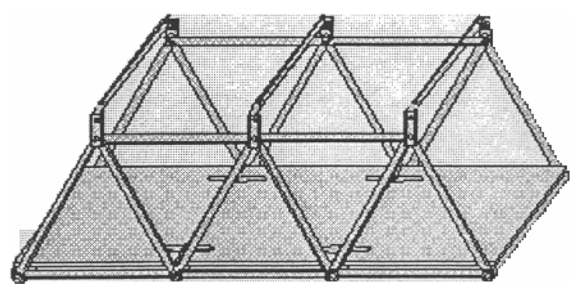
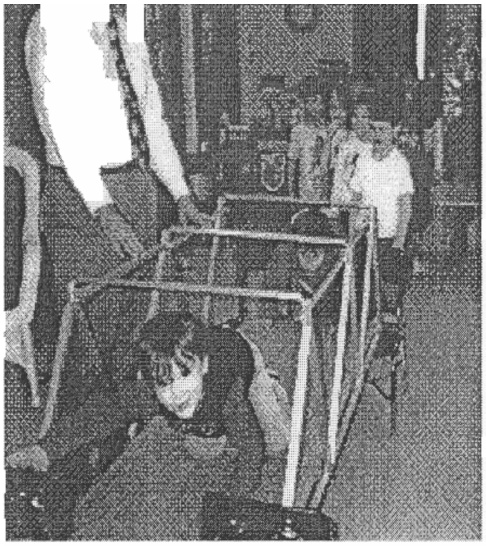


Figure 6. Shows the completed bridge.



"Does it look like a bridge now?" The bridge is sitting flat on the floor, and you don't see bridges laying flat on the ground. Bridges go across something. Two chairs in the room are placed under each end of the bridge, to make it look like a bridge. (Originally I used one chair under each end, but this made it awkward to get on and off the bridge. A teacher pointed out that placing two chairs under each end, spread apart slightly, would give them a clear path down the center of the bridge, which works much better.) The students line up, and are allowed to crawl across the bridge twice. Figure 7 shows the bridge in use. It takes about 30 minutes to construct the bridge and give everyone two opportunities to crawl across it. I generally ask the question "Do you think this bridge is strong enough for your teacher to crawl across it?" Most of the teachers are willing to give it a try. (All adults will have trouble with their rear end getting caught on the lateral braces as they try to crawl through, and will have to slide on their stomach to fit through. Large teachers will have a very difficult time fitting through the bridge, so you should size up the teacher and decide whether or not to ask. (Don't put her in an embarrassing situation.)

Up to this point there has been a lot of activity, and the students are now interested in bridges, so I begin the lecture part of the presentation. I have them sit together in a small group on the floor, so they can see the pictures I have brought. First we learn to identify the different types of bridges. The first picture is a small truss bridge very similar to the one they have built. I like this picture because it makes the bridge they have built seem more realistic. The bridge they have built has three bays, while the one in the picture is an eight bay bridge. For the younger children it is good to count the bays of the bridge together, to help them understand the bridge term "bay".

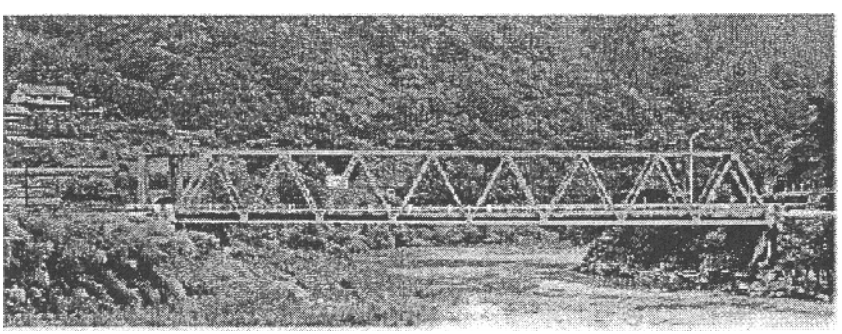


Figure 8 Eight Bay Truss Bridge

Figure 8 is a small truss bridge. Figure 9 is a much larger truss bridge with the same basic design, and figure 10 is an arched truss bridge, sometimes called a rainbow truss bridge.

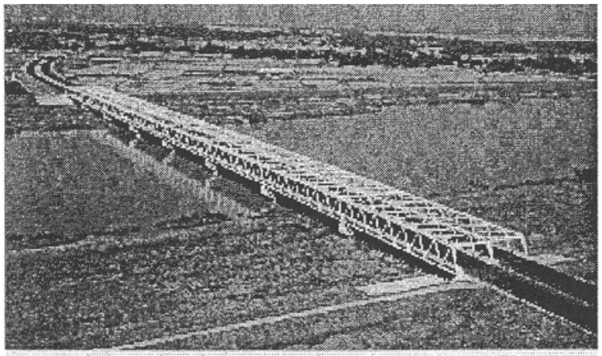


Figure 9. Large Truss Bridge.

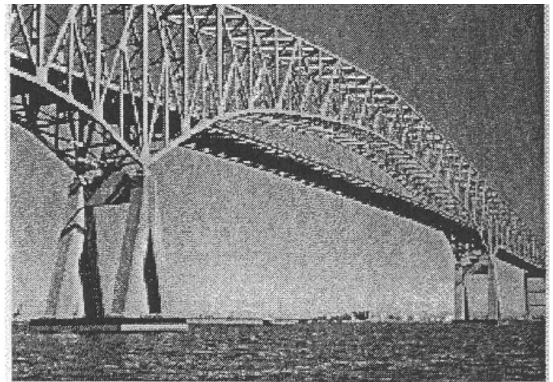


Figure 10. Arched Truss Bridge.

The next two pictures (Figures 11 and 12) are of a stone arch bridge, the Font Du Gard in southern France. This is a famous bridge, because it is one of the oldest bridges in the world that is still in good condition. The Romans in about 60 B.C.E. built it, so the bridge is more than 2000 years old. This is an aqueduct bridge; the middle level was designed to carry a channel of water for the city. In early times, when a large number of people gathered together and formed a city, it was always a problem to get enough water for the people to drink, cook, wash, etc. Aqueducts like this helped solve the water problems of the early cities, and are still used today. The bridge is now a tourist trap, and if you go to southern France you can buy a ticket and have the opportunity to walk across.

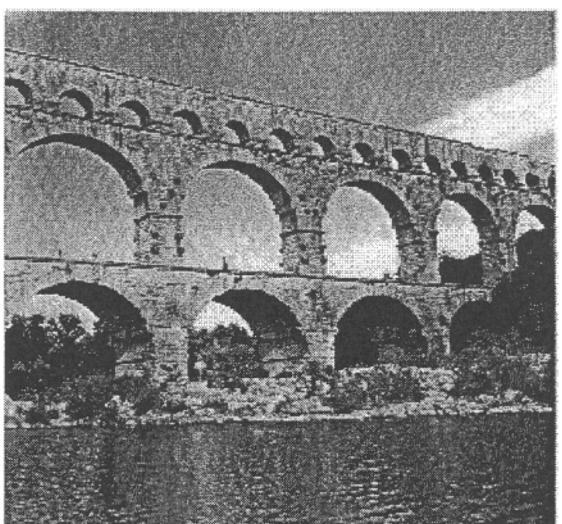


Figure 11. Pont Du Gard.

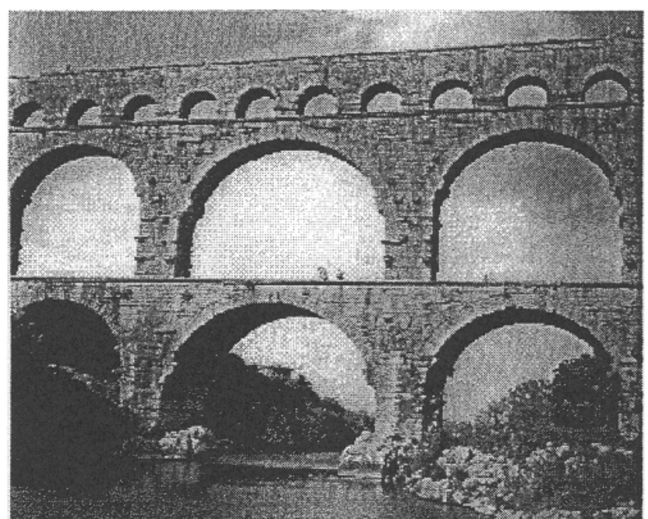


Figure 12. Pont Du Gard.

Figure 13 a very unique arch design because you actually walk on the arches. This works fine for a pedestrian bridge, but it would be a bumpy ride to drive your car over it. Figure 14 is a tied arch bridge.

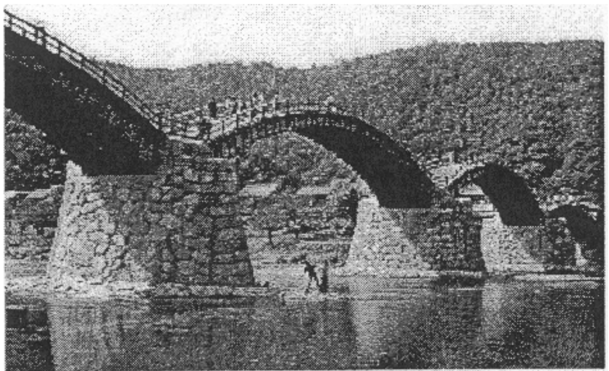


Figure 13. Pedestrian Arch Bridge.

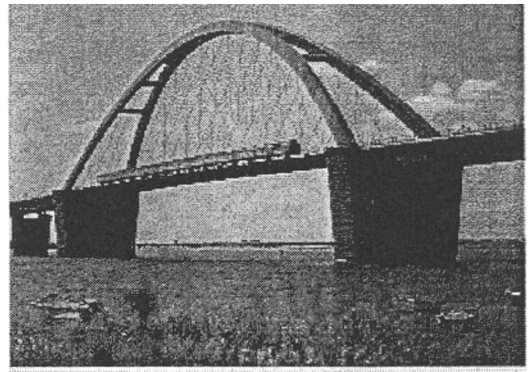


Figure 14. Tied Arch Bridge.

Figure 15 is the New River Bridge in West Virginia. It is a large steel arch bridge. I like the way it comes out of the top of one mountain, and goes across to the other mountain.

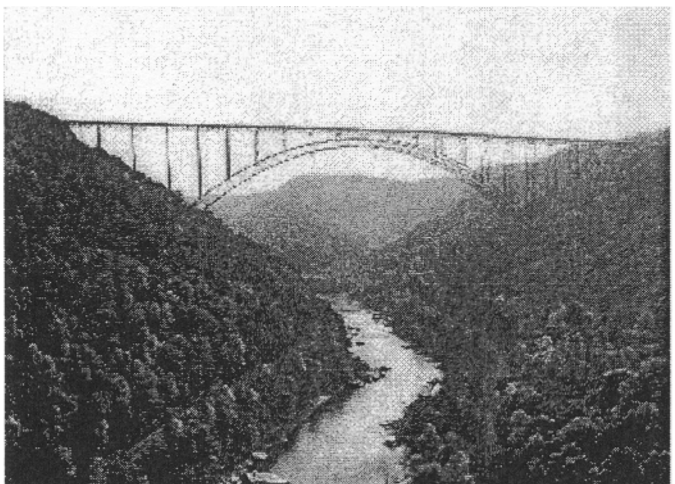


Figure 15. New River Bridge.

Figure 16 is of a large concrete girder bridge. The children do not get very excited about this one, but it is one of the most common designs, so I included it.

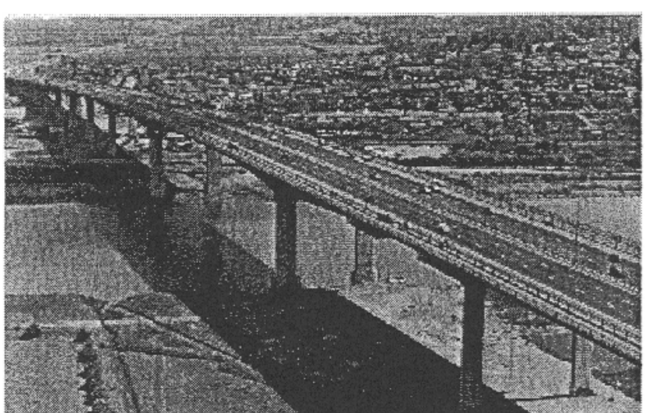


Figure 16. Concrete Girder Bridge.

Figures 17 & 18 can be contrasted to show the difference between a cable-stayed bridge and a suspension bridge. In both cases, the cables are the main structure that holds up the bridge deck. Both require very tall towers above the bridge for attaching the cables. In a cable-stayed bridge the cables are tied directly from the towers to the bridge deck. On a suspension bridge, there are catenary cables draped over the top of the towers and smaller cables are connected from the catenary cables to the decking. The catenary cables are typically about five feet in diameter. Most people do not realize just how huge these cables are. Figure 18 is the Brooklyn Bridge one of the first really good suspension bridges

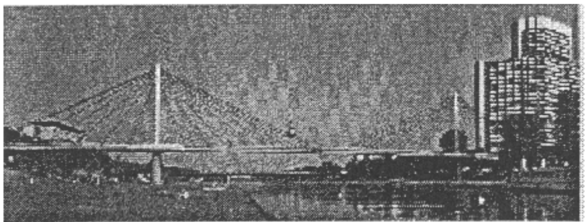


Figure 17. Cable-Stayed Bridge.

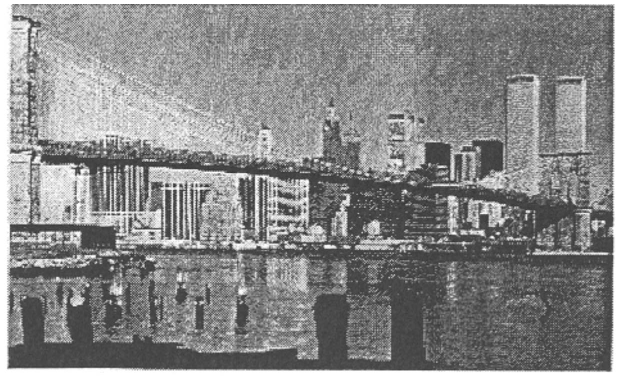


Figure18. Suspension Bridge.

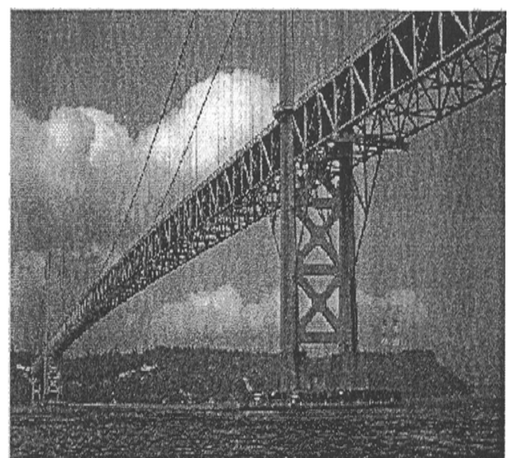
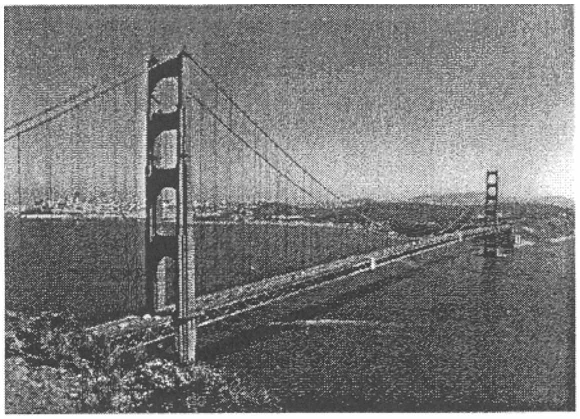


Figure 19. Tacoma Narrows Bridge

Figure 19 is the Tacoma Narrows Bridge, after it was rebuilt. This bridge originally had a thin girder type deck, rather that the truss type it currently has. The deck was very flexible, and the bridge swayed in any wind storm. The people who lived near by and used the bridge ,referred to it as "Galloping Gertie". One day a large wind storm came up and the bridge began oscillating violently. A news person filmed the bridge as it waived violently in the wind, and finally collapsed. It is a very famous film clip, that some of the children will have seen if they have visited a science center. Some people believe that the aerodynamics of the bridge was what caused it to waive so violently and fail during the wind storm. Others felt that the deck was too flexible, and that the flexibility was what caused the bridge to collapse. When the bridge was rebuilt, the decking was made much stiffer, and it no longer sways in the wind.

Figure 20 and 21 are of the Golden Gate Bridge, which is probably the most famous bridge in the world. Some will refer to it as the "Full House" bridge because of the TV series. During the gold rush in California, ship captains would deliver supplies such as food, clothing and tools to the miners. They would sail into the San Francisco bay, off-load supplies, and load the ship back up with gold. The ship captains named the two mountains that they sailed between to enter the bay "the Golden Gate", i.e. they sailed through the Golden Gate to deliver the supplies and load up with gold. So when they built the Bridge across the two mountains, they named it the Golden Gate Bridge.



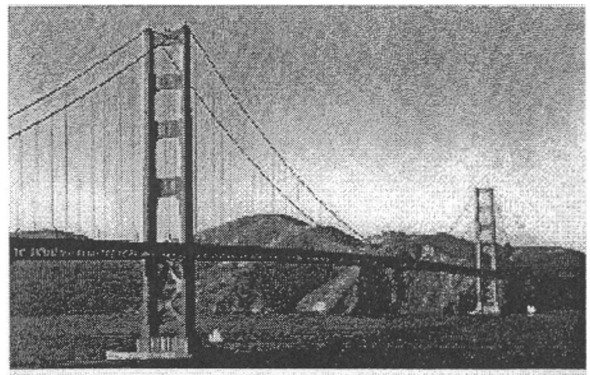


Figure 21. Golden Gate Bridge.

At this point the children are usually getting tired of sitting and listening. The next part of the presentation is to introduce them to the concepts of tension and compression. I explain that tension is stretching of the members, and compression is squeezing of the members. Some of the members in the trusses are in compression, and some are in tension. I have a chain which is brought out at this time to illustrate that chains are very strong in tension, but weak in compression. We talk about replacing one of the members in the truss with a chain. Will the bridge still be strong? I first replace one of the compression members with a chain, and show them that the bridge will collapse under even a small load. [The compression member I select is one of the diagonal members on the end of the truss.] I then replace a tension member with a chain, and show that the bridge is as strong as before. [The tension member I select is the diagonal member adjacent to the compression member that was selected.]

Some of the students understand this discussion of tension and compression and others do not. The chain is used to give a "hands-on" feel to the forces generated in the truss members as the bridge is loaded. All of the children get one more turn to crawl across the bridge, and I encourage them to touch the chain as they cross so they can "feel" the forces developed in the chain because of their weight on the bridge, as shown in Figure 22. The final part of the presentation is having the students take the bridge apart and pack it up, which is a quick process. The entire presentation takes about one hour.

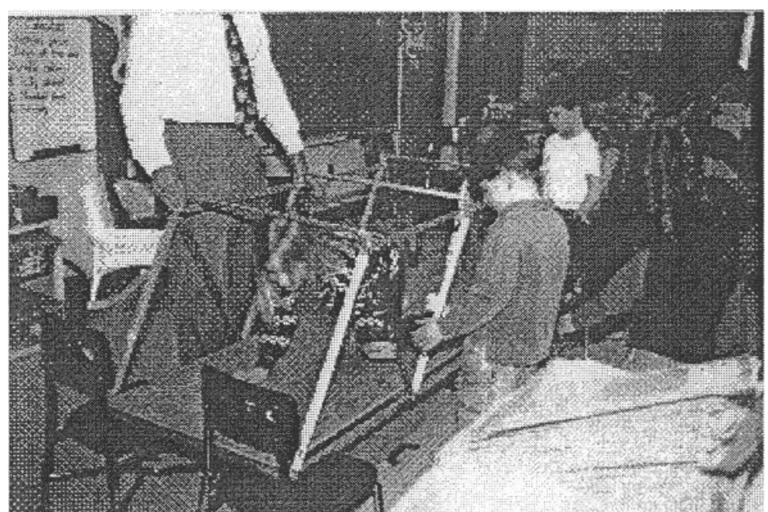


Figure 22. Chain on the Bridge.

If you need information about ordering a bridge kit, please contact Doug Carroll at the University of Missouri-Rolla, dougc@umr.edu or (573)-341-4554.

Activity 1
Introduce yourself.
Discuss various bridges.
Discuss names of bridges.
Introduce various parts of a bridge.
Work in cooperative group to discuss and learn about structures.
Organize students into groups.
Build a bridge.

Steps:
1. Lay the equipment out in order in which it will be used.
2. Place all of the same parts together.
3. Select a group of students to work on specific parts of the bridge.
4. Finally, have each group work in their designated area. Keep students interested in activity.

Explanation:

Discuss the various parts of a bridge:
The truss -
Lateral brace - A rod that is in place to support the bridge.
Floor beams – A wooden beam with two screws extended from either side.
Truss brackets – An aluminum " L" shape bracket with two holes.
Decking – A wooden base that lines the bottom of the bridge.
Wing nuts _ A nut that fits the screws on either side of the floor beam.

Demonstration

Invite wizard from the **W**izards **O**f **W**right (W.O.W) program to visit your classroom to present the demo for an exciting hands-on experience. Contact Fran Johnson, W.O.W Program manager from the Education Outreach office WPAFB Ohio @ 255-0068.

Suspension Bridge

Aesthetic, light, and strong, suspension bridges can span distances from 2,000 to 7,000 feet -- far longer than any other kind of bridge. They also tend to be the most expensive to build. True to its name, a suspension bridge **suspends** the roadway from huge main cables, which extend from one end of the bridge to the other. These cables rest on top of high towers and are secured at each end by anchorages.

Suspension bridge
Golden Gate Bridge, San Francisco, CA

Suspension bridge anchorage

Arch Bridge

Arch bridges are one of the oldest types of bridges and have great natural strength. Instead of pushing straight down, the weight of an arch bridge is carried outward along the curve of the arch to the supports at each end. These supports, called the **abutments**, carry the load and keep the ends of the bridge from spreading out. Also discuss tension and compression.

Arch Bridge
Bixby Creek Bridge, Monterey, CA

Beam Bridge

A beam or "girder" bridge is the simplest and most inexpensive kind of bridge. According to Craig Finley of Finley/ McNary Engineering, "they're basically the vanillas of the bridge world."

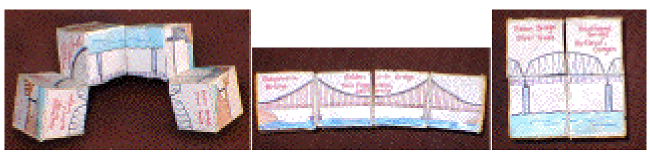
Beam bridge

Cable-Stayed Bridge

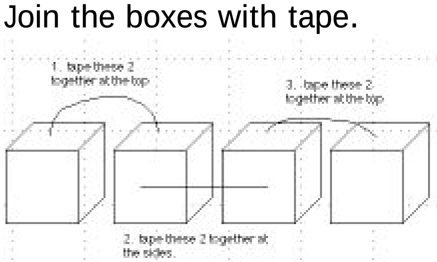
Cable-stayed bridges may look similar to suspensions bridges -- both have roadways that hang from cables and both have towers. But the two bridges support the load of the roadway in very different ways. The difference lies in how the cables are connected to the towers. In suspension bridges, the cables ride freely across the towers, transmitting the load to the anchorages at either end. In cable-stayed bridges, the cables are attached to the towers, which alone bear the load.

Cable-stayed bridge
Clark Bridge, Alton, IL

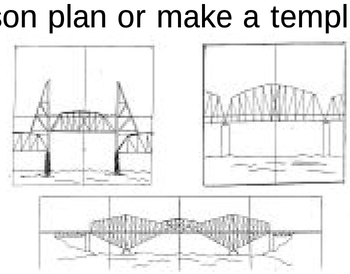
<u>Activity 2</u>
First Bridge Boxes
Click on picture for a larger picture



Run off 4 copies of a cube pattern to form the boxes. (Alternatives to Worksheets - Creative Teaching Press) This pattern is glued to railroad board. Cut out and then formed into a stiff box. Make 4 boxes in this way.
Join the boxes with tape.



Second
Using all the drawn bridges on the square or long paper, cut out the pictures and glue the parts onto the cubes.(see activity 2 of lesson plan or make a template as shown.)



Finally, you have a bridge box that you can move to show the different types of bridge architecture. You will also have identified where some of these bridges are found.

Activity 3

Building a truss bridge using toothpicks and gumdrops

Objective

Students will learn how to build a structure out of simple household products.

Time allotted

1 hour

Materials

Toothpicks,
Gumdrops,
Wax paper
Overheads Projector

Instructions

Place the model of several different bridges on the overhead for students to view. Place wax paper on the desk for students to use as a work surface. Give each student a pile of toothpicks and a few gumdrops.

Have each student build their bridge approximately twelve inches long using overheads as a reference.

Assessment

Teacher made test

1. Cover bridge vocabulary.
2. Discuss the various types of bridges.
3. Have students draw a truss bridge.

Activity 4

Topic:

Structure

Time:

Each activity can take as little as 15 minutes or launch full period lessons.

Purpose:

The activities demonstrated will give the students an opportunity to do hands on science that is cheap and easily available to the teacher. Science, creativity and teambuilding are the primary areas covered by these activities. They may be developed into larger units. A competitive environment seems to help motivate students for these activities.

Objectives:

- To understand basic structural terminology and to identify these terms in a group activity.
- To use simple items to demonstrate how design plays into structure. To offer many simple activities to demonstrate different aspects of
- Structure. -

Procedures:

The procedures for each activity will be outlined on the group activity cards.

Materials:

Each activity card will contain a supply list for that particular activity. Substitutions are welcomed and any available item can be appropriate. Some supplies generally used are:

Spaghetti	Straws, Marshmallows, String
Toothpicks	Masking Tape, Clay, Scissors
String	Paper
Paper Clips	Any Material Available
Measuring Devices	Stop watch
Weights (what ever you decide to use)	

Assessment: Various forms of assessment can be used. A competitive environment seems to motivate and points become an easy way to determine grade. Rubric templates are attached.

Activity 5

Free Standing Tower

Give each group (no more than 4 students per group) an envelope containing 2 pieces of 8 1/2 x 11 paper and 12 paper clips and a pair of scissors.

Instruct students to build the highest freestanding tower they can only using the supplies in the envelope. The envelope and scissors may not be used.

They only have 8 minutes to complete the structure.

Inform the groups that they will earn points for every inch their structure is high. The structure must stand for at least 6 second count

Record the scores

Now give the exact same amount of supplies and repeat the assignment. This time you will award bonus points for towers that are higher than their previous structure. Close the activity discussing the role design played into the product. Point out that this is what design teams do in the real world.

Student's card

Your group's assignment is to build a freestanding tower with the supplies contained in the envelope and some scissors. You may alter the supplies; however you may not use the envelope or scissors.

Before building the structure plan with your group and discuss several possibilities. You only have 8 minutes to complete this task.

Scoring
The team will receive 20 points if they have a freestanding structure at the end of 8 minutes.
The structure will receive 5 points for every inch high.
The tallest structure will receive 15 additional bonus points.

Resources and References

The Clark Bridge, Alton, Illinois
http://www.altonweb.com/history/clarkbridge/index.html

A photo history of the bridge featured in the NOVA program *Super Bridge.*

American Society of Civil Engineers
http://www.asce.org

A site for engineering professionals with information on publications, job openings, educational programs, conferences and other industry resources

Association for Bridge Construction and Design
http://abcdpittsburgh.org/

Learn about the activities of this organization devoted to improving the science of bridge design, construction and maintenance.

Bridge Research: Leading the Way to the Future
http://www.tfhrc.gov/pubrds/summer95/p95su23.htm

An article from the Turner Fairbanks Highway Research Center discussing the importance of research in maintaining America's bridges.

Matsuo Bridge Company
http://www.matsuo-bridge.co.jp/english/index.htm

A site profiling an innovative 72-year-old Japanese bridge company with a photo catalog of its bridges and descriptions of bridge construction methods.

Portland Cement Association
http://www.portcement.org/

Take a tour through the cement making process, read the latest news in the concrete industry and take the cement pond quiz.

Precast/Prestressed Concrete Institute
http://www.pci.org/

This organization is dedicated to fostering greater understanding and use of precast/prestressed concrete. Their web site offers the opportunity to search for a concrete producer in your area and learn about the uses of precast/prestressed concrete in many types of construction projects.

Boeing: Exploring Engineering

9Th Educators enrichment day
Boeing Educational outreach program
February 19, 2002

Douglas R. Carroll, PhD, PE

Associate Professor
Department of basic engineering
University of Missouri-Rolla

Book
Bridges
By Fritz Leonhardt
MIT Press, Cambridge 1990.

Vocabulary

Trusses - A truss is a type of framework, usually comprising straight struts and ties, which are designed to be stiff, even if all the joints are considered to be pinned.

Floor beams- A wooden structure that is used to allow the flooring to lie properly

Lateral brace- The aluminum support that stabilizes the top of the bridge

Wing nuts- A nut with wing like projections for thumb and forefinger leverage in turning

Coupling- A device that links or connects

Decking- To furnish with or as if with a deck